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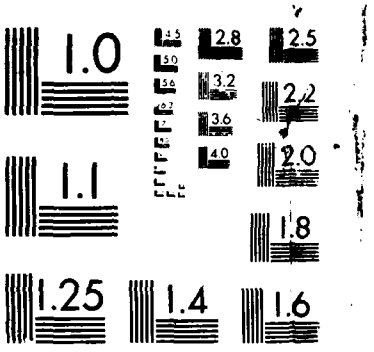

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The purpose of this grant was to purchase a hypercube computer to support DoD-sponsored research, and other research, in parallel numerical computation. The plans that were outlined in the proposal were followed very closely. We have purchased a 32-node Intel iPSC-D5 hypercube computer with the funds from this grant, and have used the matching University contribution to support the maintenance of this computer. This computer has been used, over the past year, for research in parallel numerical computation in areas including global optimization, VLSI design, large sparse systems of linear equations, and eigenvalue problems, as well as for research in the languages for parallel computation and in the debugging and measurement of parallel programs.

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Final Technical Report

U.S. Air Force Grant AFOSR-87-0055
Concurrent algorithms for Numerical Computation
on a Hypercube Computer

R. Schnabel
University of Colorado at Boulder

1 October 1986 - 30 September 1987

1. Summary

The purpose of this grant was to purchase a hypercube computer to support DoD-sponsored research, and other research, in parallel numerical computation. The plans that were outlined in the proposal were followed very closely. We have purchased a 32-node Intel iPSC-D5 hypercube computer with the funds from this grant, and have used the matching University contribution to support the maintenance of this computer. This computer has been used, over the past year, for research in parallel numerical computation in areas including global optimization, VLSI design, large sparse systems of linear equations, and eigenvalue problems, as well as for research in the languages for parallel computation and in the debugging and measurement of parallel programs.

2. Computer Equipment Purchased

The grant provided funds for the purchase of a 32-node hypercube computer. As is required by state law, the purchase of this machine was performed through a competitive bidding process. Bids were received from Intel and NCUBE, as well as one other bid for an inappropriate product. The bids were evaluated on basis of price, price/performance, hardware and software availability and reliability, maintenance, and company stability. Both vendors lent us machines to test; in fact, Intel lent us a 32-node machine commencing in August 1986, which permitted us to begin our research using these machines considerably earlier than expected.

Both the Intel and NCUBE machines were judged to be very satisfactory for the stated purposes. The decision to purchase Intel was made primarily due to price, and a perceived superiority in software availability and reliability. The purchase was officially completed in the early summer of 1987, but as stated above, the Intel computer has been present and fully operational since August 1986. The purchase price was $98,700; the remaining $1,300 of this grant, as well as the matching University contribution of $12,500, are being used for maintenance, as well as a small amount of required space remodeling.

In general we have been satisfied with the performance of the Intel computer. The incidence of hardware problems has been small. As can be expected with a new product, there have been somewhat more software problems, especially in products such as the C compiler that have not yet been used by many customers. In general we have received good response from Intel in addressing these problems.

3. Research Performed on the Hypercube

The hypercube computer has been used in virtually all of the research projects that were mentioned in the original proposal, as well as a number of interesting projects that were not anticipated at that time. These projects generally fall into the categories of parallel numerical algorithms, and software support for parallel computation. Since this grant provides equipment to support this research, but not direct support for the research itself, we just briefly summarize the research here.

Professors Byrd and Schnabel and their students have used the hypercube in several research projects in parallel methods for nonlinear optimization and systems of nonlinear equations. A parallel global optimization algorithm has been implemented on the hypercube and tested extensively. This research has involved not only the development of parallel algorithms, but also of techniques for modeling parallel algorithms. We are also developing parallel algorithms for large, block-bordered systems of nonlinear equations, which arise in VLSI design and in structural engineering, and are implementing these on the hypercube. This research is supported by AFOSR grant AFOSR-85-0251, ARO contract DAAG29-84-K-0140, and an NSF Coordinated Experimental Research (CER) grant.

Professor Hachtel and his students have utilized the hypercube to implement parallel algorithms for problems that arise in the design of VLSI circuits. A two-level tautology checking algorithm has been implemented on the hypercube, with good results. This research also is supported by AFOSR grant AFOSR-85-0251.

Professor Schnabel and his students have also developed a new language, DINO, for distributed numerical computation. Its intent in to make computers such as hypercubes considerably easier to program for numerical applications. The language consists of some high level extension to standard C. A prototype, using C++, has been implemented on the Intel hypercube. This research is supported through our NSF CER grant.

Professor Jordan and his students have used the hypercube to compare a point to point communication scheme with a global, broadcast/accumulate communication scheme. These studies have been made using a particle in cell (PIC) code.

Professor Nutt and his students have been working on modeling and debugging for parallel computation. They have used the hypercube to make measurements that analyze the effect of communication hot-spots in the cube. They have developed a set of utilities which do graphical output from the nodes of the hypercube. They are now working on a debugger for the hypercube, hooked through an interface to a Sun workstation.

Professor Farhat of the Aerospace Engineering Department, who joined our faculty after the proposal was written, has been an active user of the hypercube. His research is in parallel methods for problems in structural design, for example problems arising in the design of space structures. He has used the hypercube to implement and test some parallel solvers for large, sparse systems of linear equations, and some parallel generalized eigenvalue problem solvers.

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